The Patent Office

INVESTOR IN PEOPLE

CERTIFIED COPY OF PRIORITY DOCUMENT

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed P. Mahoney

Dated 13 AUG 1999

Patents Form 1/77

Patents Act 1977
(Rule 16)

THE PATENT OFFICE
22 JUN 1999
RECEIVED BY HAND

The Patent Office

1/77

23JUN99 E456671-13 D02224
P01/7700 0.00 - 9914598.9

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference — WBH

2. Patent application number *(if you know it)* — 9914598.9 — 22 JUN 1999

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

John Humphries PARKES
T/A Dell Explosives
Redhall Mill Cottage,
Colinton Dell,
Edinburgh
EH14 1JF

Patents ADP number *(if you know it)* 6618250001

If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

4. Title of the invention — METHOD AND APPARATUS FOR ROCKET MOTOR DISPOSAL

5. Name of your agent *(if you have one)* — J.Y. & G.W. Johnson

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Kingsbourne House,
229-231 High Holborn,
London WC1V 7DP

Patents ADP number *(if you know it)* — 976001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
GB	9820720.2	24/9/98

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	7
Claim(s)	2
Abstract	1
Drawing(s)	3

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature J Y R G W Johnson Date 22.6.99.

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr William Hanson
0171 405 0356

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

DUPLICATE

METHOD AND APPARATUS FOR ROCKET MOTOR DISPOSAL

The present invention relates to a method and apparatus for rocket motor disposal.

Large numbers of redundant munitions comprising rocket motors exist and environmentally friendly methods for their disposal are sought.

British Patent Application No. 2306884 describes a method of limiting the environmental disturbance of an exploding munition, such as a bomb, by spraying a liquid towards the munition to create a liquid dispersion which at least partly surrounds the munition and detonating the munition into the dispersion. That method is suitable for disposing of bombs, but may be unsuitable for disposing of certain rocket motors, despite the fact that these can be detonated or deflagrated without becoming propulsive.

It is an aim of the present invention to provide a safe, environmentally friendly and adaptable open burning method and apparatus for disposing of rocket motors.

According to one aspect of the invention there is provided a method for disposing of a rocket motor comprising burning propellant contained within the motor, and generating an enclosure of liquid within which the burning occurs. The enclosure or shroud of liquid captures particulate matter from the rocket motor's emissions.

In an embodiment of the invention, the liquid, which may comprise water, includes at least one neutralising chemical for neutralising noxious substances resulting from the burning and/or for capturing hazardous materials such as asbestos.

Preferably, prior to the burning step, demilitarisation or reverse engineering operations are carried out on a rocket-propelled munition of which the rocket motor forms

part. Such operations may comprise removal of a warhead, removal of an ancillary propulsion system and removal of a venturi mechanism.

The best results are achieved when the motor is secured in a substantially vertical position, with its rear or exhaust end facing upwards, during the burning step.

The method may comprise further steps of filtering liquid from said enclosure and recycling the filtered liquid to the enclosure.

According to another aspect of the invention there is provided apparatus for disposing of a rocket motor, comprising means for generating an enclosure of liquid within which propellant contained within the motor can be burnt.

Preferably, the liquid enclosure generating means comprises a nozzle having an outlet in the form of a closed figure such as a circle.

The apparatus preferably comprises means for securing the rocket motor in place. In a particular embodiment, the securing means and the liquid enclosure generating means are integral parts of the same unit.

The apparatus preferably includes a pump for conveying liquid to the enclosure generating means. Filtering means for filtering liquid from the enclosure may also be included, as may a submersible pump for returning the liquid to a reservoir from which it may once again be conveyed to the enclosure generating means.

Deflecting means such as a hood and a conduit of large diameter may optionally be provided for directing the exhaust plume and aerosolised liquid to a non-damaging location.

The present invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is an elevation of a nozzle/securing unit according to an embodiment of the invention;

Figure 2 is a plan of the unit shown in Figure 1;

Figure 3 is a vertical section of the unit shown in Figures 1 and 2, taken along the line III-III in Figure 2;

Figure 4 shows a detail of the section shown in Figure 3;

Figure 5 schematically shows the unit of Figures 1 to 4 in use; and

Figure 6 is a schematic plan of apparatus according to an embodiment of the invention including the unit of Figures 1 to 5.

Figures 1 to 4 show a unit 1 for securing a rocket motor and generating a liquid enclosure around burning propellant from the motor. The unit 1 comprises a frame 2 mounted on an open rectangular base 3. Adjustable clamps 4 provided on the frame 2 can be tightened to secure a rocket motor in place in the unit 1 with the rear or exhaust end of the motor facing upwards.

A pipe 5 mounted in a square around the bottom of the frame 2 has an inlet 6 to which a high pressure pipeline can be fitted in a liquid-tight manner. A number (eight in this example) of vertical pipes 7 leads from the annular pipe 5 to an annular nozzle 8 mounted around the top of the frame 2. A detailed cross-section of the nozzle 8 is shown in Figure 4. The nozzle has a continuous annular outlet 9 having a radial width of typically 1.5mm. Larger radial widths can be engineered if greater water flows are required.

Prior to the burning of its propellant, demilitarisation or reverse engineering operations are carried out on a rocket-propelled munition to be disposed of. Firstly, the warhead (which may or may not be explosive) and any ancillary means of propulsion are removed. Having thusly separated the rocket motor from the missile it is advisable, but not necessary, to remove the rocket motor's venturi mechanism. Such removal creates a less energetic exhaust flow and allows the formation of a denser and more easily contained exhaust cloud. If removal of the venturi mechanism is difficult or dangerous then the apparatus of the invention can be designed to deal with rocket motors still having a venturi mechanism.

As shown in Figure 5, in use, the unit 1 is weighted down by placing heavy weights 10 on the base 3 of the unit. A high-pressure pipeline 11 is connected to the inlet 6. A rocket motor 12 is then placed in the frame 2 and the clamps 4 are tightened around the rocket motor.

Water, optionally containing one or more neutralising chemicals or minerals, is then forced through the pipeline 11, into the annular pipe 5, up the vertical pipes 7 and out of the outlet 9 of the annular nozzle 8. In this manner a cylindrical enclosure 13 of water is formed, completely surrounding the exhaust plume 14 of the rocket motor 12. The water enclosure 13 captures noxious particulate matter exhausted from the burning propellant and thus keeps such matter on the already contaminated land of a purpose built munitions disposal facility and prevents exhaust emissions from entering the atmosphere.

Figure 6 is a schematic plan of such a facility. Water is supplied from a supply tank 15, in which pre-mixing of neutralising or decontaminating agents can take place if required, to a high pressure, high volume pump 16. The pump 16 can be driven by a fuel burning engine or by an electric motor, at least one large diesel engine being preferred for field operations.

The pump 16 forces water through the high pressure pipeline 11 to the unit 1. The area of ground on which the unit 1 is situated is provided with either a suitable pavement or a heavy duty membrane and has a slight gradient running downwards in the direction of the arrows. This means that contaminated water from the enclosure flows into a catchment tank 17 where particles suspended in the water are allowed to settle. The catchment apron optionally includes a chalk or lime bed for neutralising acids from the rocket motor exhaust.

A submersible pump 18 is located in the catchment tank 17, spaced from the bottom of the tank so as to prevent sediment in the tank being drawn into the pump 18. The submersible pump is preferably hydraulically driven but may alternatively be electric. The pump 18 transfers the water to a filtration plant 19 and thence back to the supply tank 15 via a low pressure pipeline 20. Filtration beds could alternatively or additionally be included in the catchment tank 17. Preferably, there are two catchment tank 17 which are used alternately so that the sediment layer can be periodically recovered, treated and disposed of.

Whilst most of the water is recycled as described above, some topping-up of the supply tank 15 will be necessary as a result of evaporation.

The apparatus is portable and can be mounted on a trailer assembly for transportation and field use if the movement of rocket motors would present problems of logistics or safety.

Preliminary calculations which were used to design a nozzle and clamping unit according to the invention are given below:-

Burn rate $m := \frac{MF}{T}$ $m = 1.16$ kg/sec

Assume that the density of the cold exhaust gases would be $\rho C := 1$ kg/m3

Assume that the exhaust temperature is 3500 K. The volume of gas per second is

$vol := m \cdot \frac{3500}{300} \cdot \rho C$ $vol = 13.55$ m3/sec

Guess rocket body diameter $DR = 0.3$ metres

The velocity of the gas is $velG := \frac{vol}{0.25 \cdot \pi \cdot DR^2}$ $velG = 191.64$ m/sec

Rocket thrust $FT := m \cdot velG$ $FT = 222.52$ Newtons

Note that this would be much higher if the gases went through a Venturi.

The working pressure of the water pump is $P = 8.5 \cdot 10^5$ Pascal

With efficient nozzles the water velocity $velW := \sqrt{\frac{2 \cdot P}{998}}$ $velW = 41.27$ m/sec

Note that is this fast enough to induce cavitation round any sharp bend so we want a gentlle convergence to the nozzle exit.

The area of the water jet nozzle will be $Anozz := \frac{Q}{velW}$ $Anozz = 1.53 \cdot 10^{-3}$ m2

Nozzle gap is $t := \frac{Anozz}{\pi \cdot kN \cdot DR}$ $t = 1.47 \cdot 10^{-3}$ metres

A sensible value would be t = 1.5 mm

Guess heat of combustion $H := m \cdot 25 \cdot 10^6$ $H = 2.9 \cdot 10^7$ Joules/sec

Latent heat of water $LH := Q \cdot 1000 \cdot 2.25 \cdot 10^6$ $LH = 1.42 \cdot 10^8$ Joules/sec

The ratio of latent heat of boiling to heat in rocket exhaust is $\frac{LH}{H} = 4.88$

CONTROL PANEL

Rocket diameter	$DR \equiv 0.3$	Burn time	$T \equiv 180$
Nozzle to rocket diam.	$kN \equiv 1.1$	Pump pressure	$P \equiv 8.5 \cdot 10^5$
Fuel weight	$MF \equiv 209$	Pump flow	$Q \equiv 0.063$

Apparatus including a nozzle/clamping unit was constructed according to these criteria and tested against the live open burning of two rocket motors as a control. About 5 tonnes of water were pumped through the nozzle per minute. The apparatus achieved a dramatic reduction in exhaust emission. Noise was also greatly reduced and this is a further advantage of the invention. After the test, many tonnes of contaminated water were found to have been deposited downwind of the burning site.

CLAIMS

1. A method for disposing of a rocket motor comprising burning propellant contained within the motor and generating an enclosure of liquid within which the burning occurs.

2. A method according to claim 1, wherein the liquid includes at least one neutralising chemical for neutralising noxious substances resulting from the burning and/or for capturing hazardous materials such as asbestos.

3. A method according to claim 1 or 2, wherein a venturi mechanism of the rocket motor is removed prior to the burning step.

4. A method according to claim 1, 2 or 3, wherein the motor is secured in a substantially vertical position, with its rear or exhaust end facing upwards, during the burning step.

5. A method according to any preceding claim, comprising further steps of filtering liquid from said enclosure and recycling the filtered liquid to the enclosure.

6. A method of disposing of a rocket motor, substantially as described herewith with reference to figures 5 and 6 of the accompanying drawings.

7. Apparatus for disposing of a rocket motor, comprising means for generating an enclosure of liquid within which propellant contained within the motor can be burnt.

8. Apparatus according to claim 7, wherein the liquid enclosure generating means comprises a nozzle having an outlet in the form of a closed figure.

9. Apparatus according to claim 7 to 8, comprising means for securing the rocket motor in place.

10. Apparatus according to claim 9, wherein the securing means and the liquid enclosure generating means are integral parts of the same unit.

11. Apparatus according to any one of claims 7 to 10, including a pump for conveying liquid to the enclosure generating means.

12. Apparatus according to any one of claims 7 to 11, including filtering means for filtering liquid from the enclosure.

13. Apparatus according to any one of claims 7 to 12, including a submersible pump for returning liquid from the enclosure to a reservoir from which it may once again be conveyed to the enclosure generating means.

14. Apparatus according to any one of claims 7 to 13, including deflecting means for directing an exhaust plume and aerosolised liquid to a non-damaging location.

15. Apparatus for disposing of a rocket motor, substantially as described herein with reference to the accompanying drawings.

ABSTRACT

METHOD AND APPARATUS FOR ROCKET MOTOR DISPOSAL

A method of disposing of a rocket motor 12 comprises burning propellant contained within the motor and generating an enclosure 13 of liquid within which the burning occurs. Apparatus for carrying out the method comprises a nozzle/clamping unit 1 for securing the rocket motor 12 in place and generating the liquid enclosure 13. The liquid, which, may be water and may include neutralizing chemicals, is filtered and recycled.

(Figure 5)

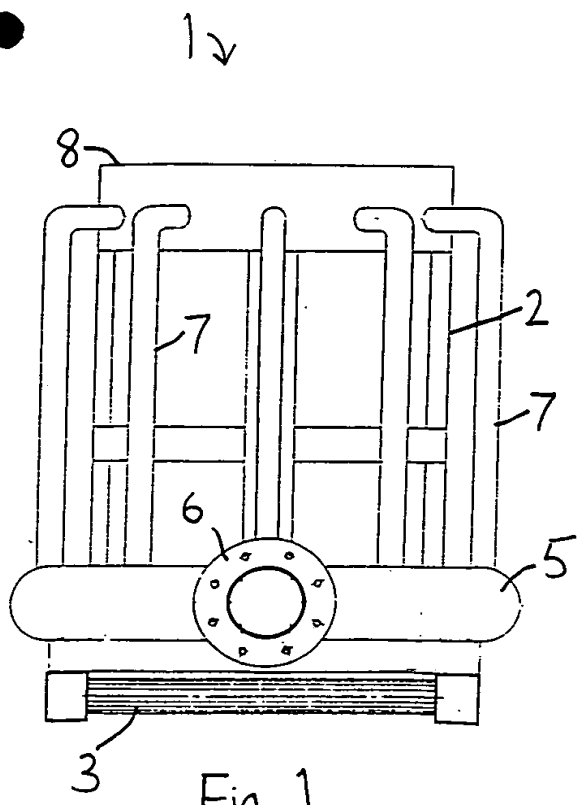


Fig. 1

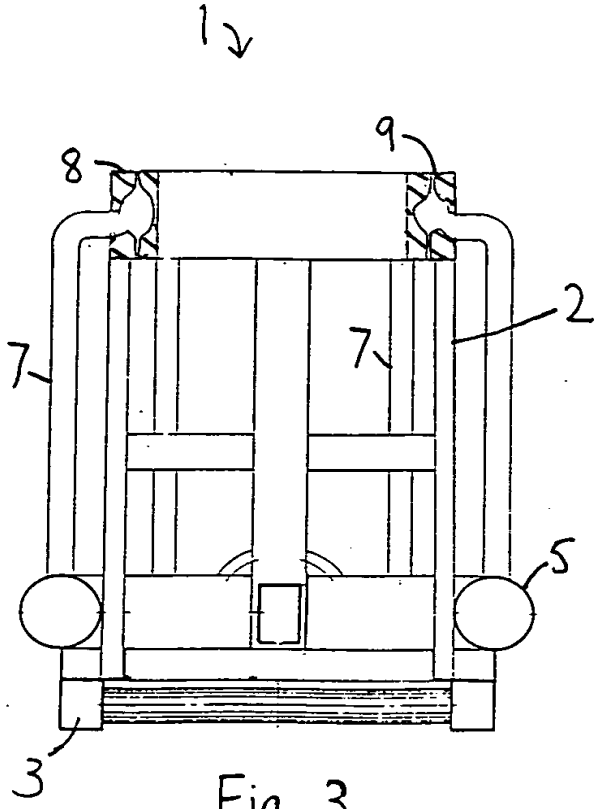


Fig. 3

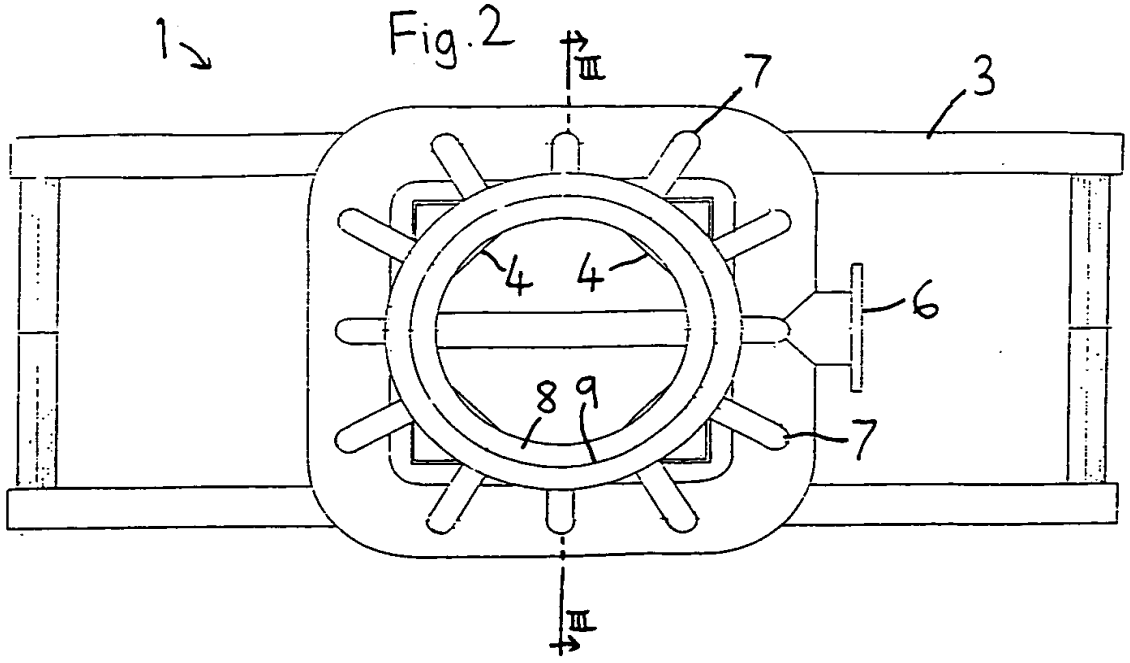


Fig. 2

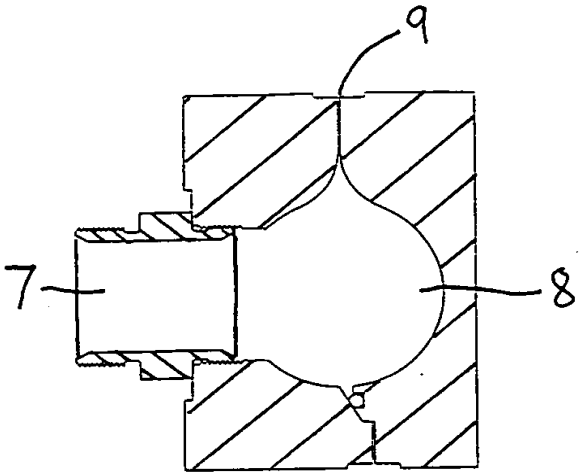
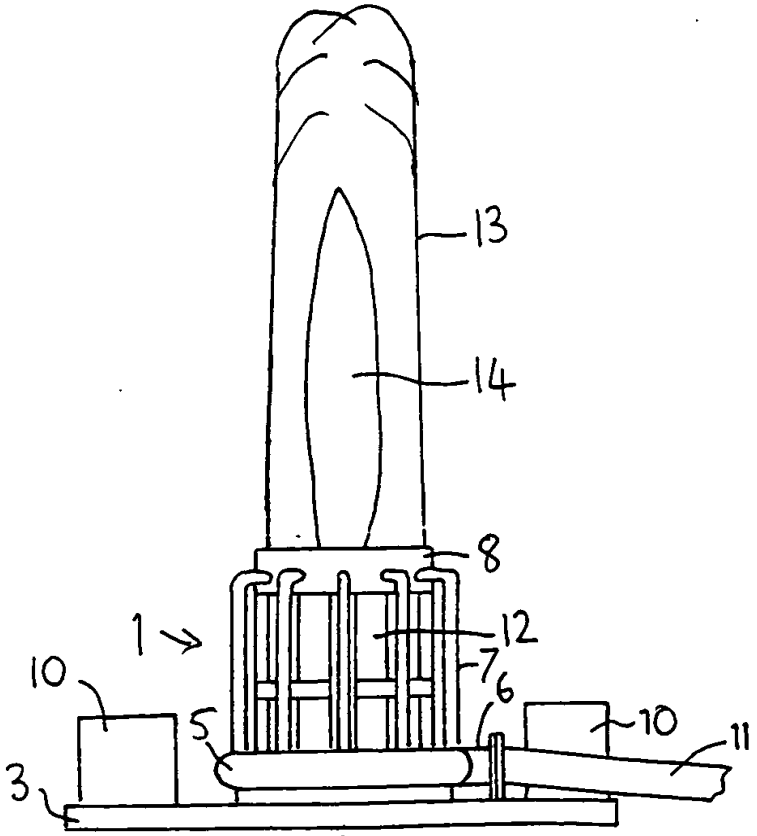


Fig.4

Fig.5



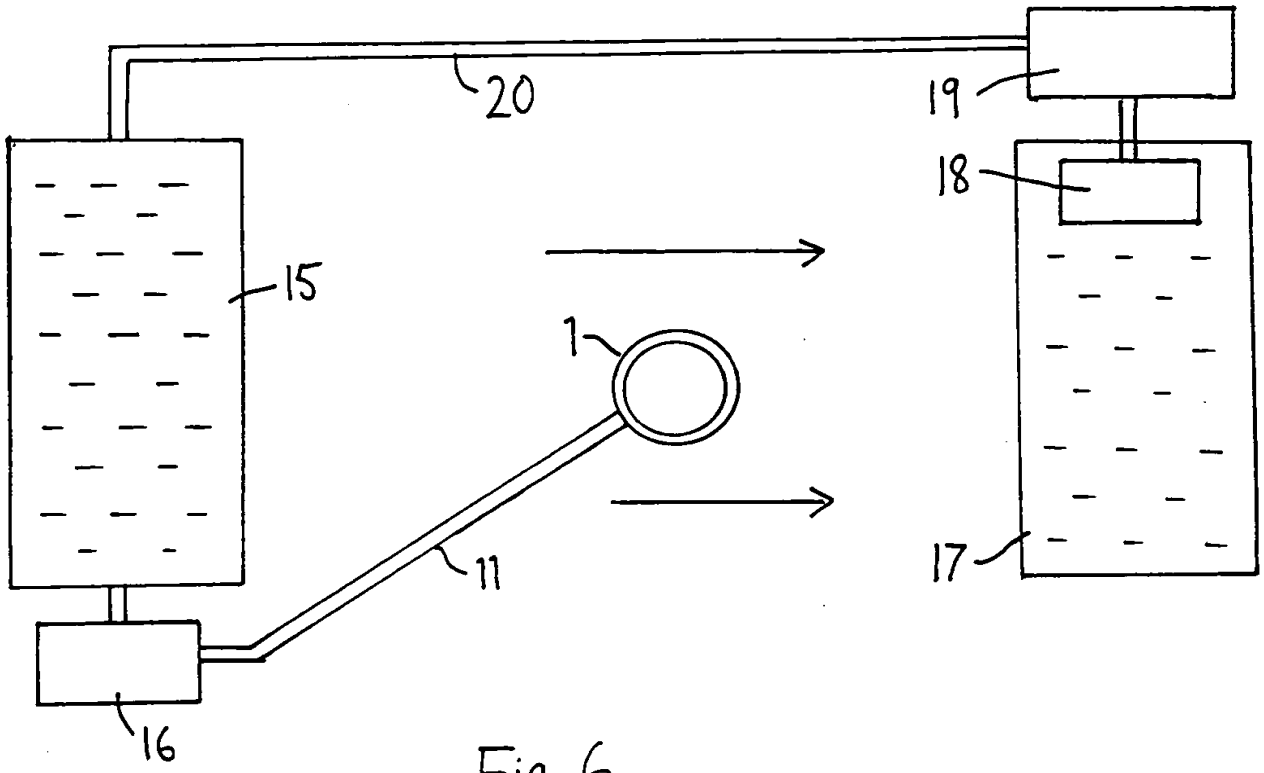


Fig. 6